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(54) **Method for processing video data for a display device**

(57) The invention is related two a new kind of pre-processing for plasma display panel control. The plasma display technology has the drawback of a reduced grey scale portrayal. This is due to the fact that contrarily to CRTs where luminance is approximately quadratic to the applied cathode voltage, luminance is linear to the number of discharge pulses in PDPs. Therefore, an approximately quadratic degamma function has to be applied to the input video signal components R,G,B before sub-field coding can be done. Truncation to 8-bit video data is required, so that the effect of the degamma function cannot be fully maintained. Especially in the region of small video levels, where the eye sensitivity is high, the grey scale portrayal is poor.

According to the invention it is proposed to use a new kind of dithering, adapted to the PDP specialities to improve the grey scale portrayal. These adaptation includes three dithering specialities which can be used singly or in combination. These are:

• cell-based dithering, i.e. to each colour component R, G, B of a pixel separate dithering numbers are added;
• object/region-based dithering, i.e. the set of disposabl dithering numbers is made depend nt on the r gion/object in the video picture;
• the set of disposable dithering numbers is made dependent on the video (signal) level.

Fig. 3

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Description

[0001]   The invention relates to a m thod for proc ssing video picture data for display on a display d vice.
More specifically the inv ntion is closely r lated to a kind of video processing for improving the picture quality of pictures
which are displayed on matrix displays like plasma display pan ls (PDP) or oth r display d vices wh re th pixel values
control the generation of a corresponding number of small lighting pulses on the display.

Background

[0002]   The Plasma technology now makes it possible to achieve flat colour panel of large size (out of the CRT
limitations) and with very limited depth without any viewing angle constraints.
[0003]   Referring to the last generation of European TV, a lot of work has been made to improve its picture quality.
Consequently, a new technology like the Plasma one has to provide a picture quality as good or better than standard
TV technology. On one hand, the Plasma technology gives the possibility of "unlimited" screen size, of attractive
thickness ... but on the other hand, it generates new kinds of artefacts which could degrade the picture quality.
[0004]   Most of these artefacts are different as for CRT TV pictures and that makes them more visible since people
are used to see the old TV artefacts unconsciously.
[0005]   A Plasma Display Panel (PDP) utilizes a matrix array of discharge cells which could only be "ON" or "OFF".
Also unlike a CRT or LCD in which grey levels are expressed by analogue control of the light emission, a PDP controls
the grey level by modulating the number of light pulses per frame (sustain pulses). This time-modulation will be inte-
grated by the eye over a period corresponding to the eye time response.
[0006]   Since the video amplitude determines the number of light pulses, occurring at a given frequency, more am-
plitude means more light pulses and thus more "ON" time. For this reason, this kind of modulation is also known as
PWM, pulse width modulation.
[0007]   This PWM is responsible for one of the PDP image quality problems: the poor grey scale portrayal quality,
especially in the darker regions of the picture. This is due to the fact, that the displayed luminance is linear to the
number of pulses, but the eye response and its sensitivity to noise is not linear. In darker areas the eye is more sensitive
than in brighter areas. This means that even though modern PDPs can display e.g. 255 discrete video levels for each
colour component R,G,B, the quantisation error will be quite noticeable in the darker areas. Further on, the required
degamma function in PDP displays, increases quantisation noise in video dark areas, resulting in a perceptible lack
of resolution.
[0008]   There are known some solutions which use a dithering method for reducing the perceptibility of quantisation
noise. These solutions are however not oriented to the nature of the display and of the displayed video. Proposed
dithering methods in the literature were mainly developed to improve quality of non-moving black and white images
(fax application and newspaper photo portrayal). The obtained results are therefore not optimal if the same dithering
algorithms are directly applied to PDPs.

Invention

[0009]   To overcome the drawback of reduced grey scale portrayal, the present invention, reports a dithering technique
adapted to the specific problems in PDPs.
[0010]   To achieve a better grey scale portrayal, a dithering signal is added to the video signal, before truncation to
the final video grey scale amplitude bit resolution. As mentioned before, dithering per se is a well-known technique
from the technical literature, used to reduce the effects of quantisation noise due to a reduced number of displayed
resolution bits. With dithering, some artificial levels are added in-between the existing video levels. This improves the
grey scale portrayal, but on the other hand adds high frequency, low amplitude dithering noise which is perceptible to
the human viewer only at a small viewing distance.
[0011]   The solution according to the invention makes an adaptation of the dithering signal to the PDP specialities in
order to achieve an optimised grey-scale portrayal and a minimised dithering noise at the same time. There are three
concrete techniques which can be used singly or in combination for the optimisation consists of three one or more of
the following techniques:

-   Cell-based dithering: adaptation to the cell structure of the plasma display.

-   Object-based dithering: adaptation to the structure of the displayed video picture.

-   Amplitude-based dithering: adaptation to the amplitude level of the pixels or pixel regions in the display d video
    picture.

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[0012] Cell-bas d dithering consists in adding a dithering signal that is defined for every plasma cell (there ar 3 plasma cells R,G,B for each pixel) and not for every pixel. This makes the dithering n is finer and less noticeable to the human vi wer.

[0013] Object-based dithering means enabling addition of a dithering signal only for certain picture content objects, or to adapt the set of disposable dithering numbers to the bit resolution of the displayed objects. In other words, the bit resolution for the dithering numbers is made adaptive to the bit resolution of the displayed objects. Two examples will help to clarify this idea:

1. OSD (On-Screen Display) is mostly generated with 4-bits of resolution per colour component R,G,B. This means that the display grey scale resolution (8 bit for each colour component R,G,B) is more than enough to correctly portray this kind of OSD, and therefore adding a dithering signal would only add dithering noise, without bringing a noticeable benefit.

2. If a PC graphic card is connected to the plasma display, for instance in 256-color mode, it is also useless to add a dithering signal. The bit resolution for each colour component R,G,B is also very low in this mode. Use of a dithering technique would not improve the grey scale portrayal. It is likely that the graphics card would add in series an own dithering signal to compensate for the reduced number of colours.

[0014] Amplitude-based dithering means that the set of disposable dithering numbers is made a function of the amplitude of the video signal components. Also here, in other words, this could be expressed that the bit resolution for the dithering numbers is made adaptive to the video signal component amplitude. Contrary to the smaller (darker) video values, large values of video do not loose bit resolution with the application of the quadratic degamma function. Therefore, the number of dithering bits can be reduced as a function of the amplitude.

[0015] Further advantageous embodiments are apparent from the dependent claims.

Drawings

[0016] Exemplary embodiments of the invention are illustrated in the drawings and are explained in more detail in the following description.

Fig. 1   shows an illustration for the plasma cell activation with small pulses in sub-fields;

Fig. 2   shows an illustration for pixel-based and cell-based dithering;

Fig. 3   shows an illustration of a 3-dimensional cell-based dithering pattern;

Fig. 4   shows a block diagram of a circuit implementation of the invention in a PDP.

Exemplary embodiments

[0017] In Fig. 1, the general concept of light generation in plasma display panels is illustrated. As mentioned before, a plasma cell can only be switched on or off. Therefore, the light generation is being done in small pulses where a plasma cell is switched on. The different colours are produced by modulating the number of small pulses per frame period. To do this a frame period is subdivided in so called sub-fields SF. Each sub-field SF has assigned a specific weight which determines how many light pulse are produced in this sub-field SF. Light generation is controlled by sub-field code words. A sub-field code word is a binary number which controls sub-field activation and inactivation. Each bit being set to 1 activates the corresponding sub-field SF. Each bit being set to 0 inactivates the corresponding sub-field SF. In an activated sub-field SF the assigned number of light pulses will be generated. In an inactivated sub-field there will be no light generation. A typical sub-field organisation with 12 sub-fields SF is shown in Fig. 1. The sub-field weights are listed at the top of the figure.

[0018] The frame period is illustrated slightly longer than all the sub-field periods together. This has the reason that for non-standard video sources the video line may be subject of jittering and to make sure that all sub-fields SF fits into the jittering video line, the total amount of time for all sub-fields SF is slightly shorter than a standard video line.

[0019] For clarification, a definition of th term sub-field is giv n here: A sub-field is a period of time in which successively the following is being done with a cell:

1. Ther is a writing/addressing p riod in which the cell is either brought to an excited state with a high voltag or with lower voltage to a neutral state.

2. There is a sustain period in which a gas discharge is made with short voltage pulses which lead to corresponding short lighting pulses. Of course only the cells previously excited will produce lighting puls s.
There will not be a gas discharge in th cells in neutral state.
3. There is an erasing period in which the charg of the cells is quenched.

[0020] As mentioned before, plasma us s PWM (pulse width modulation) to g nerate the different shades of grey. Contrarily to CRTs where luminance is approximately quadratic to the applied cathode voltage, luminance is linear to the number of discharge pulses in PDPs. Therefore, an approximately quadratic degamma function has to be applied to the input video signal components R,G,B before the PWM.

[0021] The effect of this degamma function on the input video data is shown in the following table, where a quadratic degamma function is applied (calculated with 16-bit resolution). After applying the quadratic degamma function to the input video data, in the next column the effect of this degamma function is depicted. The numbers in this column were achieved after dividing the quadratic numbers in the previous column by 256 and truncation. By doing this it is assured that the output video range and the input video range is identical.

8 Bit Input Video Data (X)	16 Bit Degamma Data (X**2)	8 Bit Output Video Data (X**2/255)	11 Bit Degamma Data (X**2)/ 32	8 Bit Input Video Data (X)	16 Bit Degamma Data (X**2)	8 Bit Output Video Data (X**2/255)	11 Bit Degamma Data (X**2)/ 32
0	0	0	0	128	16384	64	512
1	1	0	0	129	16641	65	520
2	4	0	0	130	16900	66	528
3	9	0	0	131	17161	67	536
4	16	0	0	132	17424	68	544
5	25	0	0	133	17689	69	552
6	36	0	1	134	17956	70	561
7	49	0	1	135	18225	71	569
8	64	0	2	136	18496	72	578
9	81	0	2	137	18769	73	586
10	100	0	3	138	19044	74	595
11	121	0	3	139	19321	75	603
12	144	0	4	140	19600	76	612
13	169	0	5	141	19881	77	621
14	196	0	6	142	20164	79	630
15	225	0	7	143	20449	80	639
16	256	1	8	144	20736	81	648
17	289	1	9	145	21025	82	657
18	324	1	10	146	21316	83	666
19	361	1	11	147	21609	84	675
20	400	1	12	148	21904	85	684
21	441	1	13	149	22201	87	693
22	484	1	15	150	22500	88	703
23	529	2	16	151	22801	89	712
24	576	2	18	152	23104	90	722
25	625	2	19	153	23409	91	731

(continued)

8 Bit Input Video Data (X)	16 Bit Degamma Data (X**2)	8 Bit Output Video Data (X**2/255)	11 Bit Degamma Data (X**2)/32	8 Bit Input Video Data (X)	16 Bit Degamma Data (X**2)	8 Bit Output Video Data (X**2/255)	11 Bit Degamma Data (X**2)/32
26	676	2	21	154	23716	93	741
27	729	2	22	155	24025	94	750
28	768	3	24	156	24336	95	760
29	841	3	26	157	24649	96	770
30	900	3	28	158	24964	97	780
31	961	3	30	159	25281	99	790
32	1024	4	32	160	25600	100	800
33	1089	4	34	161	25921	101	810
34	1156	4	36	162	26244	102	820
35	1225	4	38	163	26569	104	830
36	1296	5	40	164	26896	105	840
37	1369	5	42	165	27225	106	850
38	1444	5	45	166	27556	108	861
39	1521	5	47	167	27889	109	871
40	1600	6	50	168	28224	110	882
41	1681	6	52	169	28561	112	892
42	1764	6	55	170	28900	113	903
43	1849	7	57	171	29241	114	913
44	1936	7	60	172	29584	116	924
45	2025	7	63	173	29929	117	935
46	2116	8	66	174	30276	118	946
47	2209	8	69	175	30625	120	957
48	2304	9	72	176	30976	121	968
49	2401	9	75	177	31329	122	979
50	2500	9	78	178	31684	124	990
51	2601	10	81	179	32041	125	1001
52	2704	10	84	180	32400	127	1012
53	2809	11	87	181	32761	128	1023
54	2916	11	91	182	33124	129	1035
55	3025	11	94	183	33489	131	1046
56	3136	12	98	184	33856	132	1058
57	3249	12	101	185	34225	134	1069
58	3364	13	105	186	34596	135	1081
59	3481	13	108	187	34969	137	1092
60	3600	14	112	188	35344	138	1104

(continued)

8 Bit Input Video Data (X)	16 Bit Degamma Data (X**2)	8 Bit Output Video Data (X**2/255)	11 Bit Degamma Data (X**2)/32	8 Bit Input Video Data (X)	16 Bit Degamma Data (X**2)	8 Bit Output Video Data (X**2/255)	11 Bit Degamma Data (X**2)/32
61	3721	14	116	189	35721	140	1116
62	3844	15	120	190	36100	141	1128
63	3969	15	124	191	36481	143	1140
64	4096	16	128	192	36864	144	1152
65	4225	16	132	193	37249	146	1164
66	4356	17	136	194	37636	147	1176
67	4489	17	140	195	38025	149	1188
68	4624	18	144	196	38416	150	1200
69	4761	18	148	197	38809	152	1212
70	4900	19	153	198	39204	153	1225
71	5041	19	157	199	39601	155	1237
72	5184	20	162	200	40000	156	1250
73	5329	20	166	201	40401	158	1262
74	5476	21	171	202	40804	160	1275
75	5625	22	175	203	41209	161	1287
76	5776	22	180	204	41616	163	1300
77	5929	23	185	205	42025	164	1313
78	6084	23	190	206	42436	166	1326
79	6241	24	195	207	42849	168	1339
80	6400	25	200	208	43264	169	1352
81	6561	25	205	209	43681	171	1365
82	6724	26	210	210	44100	172	1378
83	6889	27	215	211	44512	174	1391
84	7056	27	220	212	44944	176	1404
85	7225	28	225	213	45369	177	1417
86	7396	29	231	214	45796	179	1431
87	7569	29	236	215	46225	181	1444
88	7744	30	242	216	46656	182	1458
89	7921	31	247	217	47089	184	1471
90	8100	31	253	218	47524	186	1485
91	8281	32	258	219	47961	188	1498
92	8464	33	264	220	48400	189	1512
93	8649	33	270	221	48841	191	1526
94	8836	34	276	222	49284	193	1540
95	9025	35	282	223	49729	195	1554

(continu d)

8 Bit Input Video Data (X)	16 Bit Degamma Data (X^{2})	8 Bit Output Video Data ($X^{2}/255$)	11 Bit Degamma Data (X^{2})/32	8 Bit Input Video Data (X)	16 Bit Degamma Data (X^{2})	8 Bit Output Video Data ($X^{2}/255$)	11 Bit Degamma Data (X^{2})/32
96	9216	36	288	224	50176	196	1568
97	9409	36	294	225	50625	198	1582
98	9604	37	300	226	51076	200	1596
99	9801	38	306	227	51529	202	1610
100	10000	39	312	228	51984	203	1624
101	10201	40	318	229	52441	205	1638
102	10404	40	325	230	52900	207	1653
103	10609	41	331	231	53361	209	1667
104	10816	42	338	232	53824	211	1682
105	11025	43	344	233	54289	212	1696
106	11236	44	351	234	54756	214	1711
107	11449	44	357	235	55225	216	1725
108	11664	45	364	236	55696	218	1740
109	11881	46	371	237	56169	220	1755
110	12100	47	378	238	56644	222	1770
111	12321	48	385	239	57121	224	1785
112	12544	49	392	240	57600	225	1800
113	12769	50	399	241	58081	227	1815
114	12996	50	406	242	58564	229	1830
115	13225	51	413	243	59049	231	1845
116	13456	52	420	244	59536	233	1860
117	13689	53	427	245	60025	235	1875
118	13924	54	435	246	60516	237	1891
119	14161	55	442	247	61009	239	1906
120	14400	56	450	248	61504	241	1922
121	14641	57	457	249	62001	243	1937
122	14884	58	465	250	62500	245	1953
123	15129	59	472	251	63001	247	1968
124	15376	60	480	252	63504	249	1984
125	15625	61	488	253	64009	251	2000
126	15876	62	496	254	64516	253	2016
127	16129	63	504	255	65025	255	2032

[0022] As it can be se n from the values in the columns headed 8 bit output video data, for smaller input values, many input levels are mapped to the same output level. This is due to division by 255 and truncation. In other words, for darker areas, the quantisation step is higher than for the higher areas which corresponds to non-linear quantisation. In particular the values smaller than 16 are all mapped to 0 (this corresponds to four bit video data resolution which is

unacceptable for video signal processing).

[0023] Dithering is a known techniqu for avoiding to loose amplitude resolution bits due to truncati n. This t chniqu only works if the required resolution is available before the truncation step. But this is th case in the present application, because the video data after degamma operation has 16 bit resolution and in the corresponding columns there ar no two id ntical values. Dithering can in principle bring back as many bits as those lost by truncation. However, the dithering nois frequ ncy decreases, and ther fore becomes more noticeable, with the number of dithering bits.

[0024] 1 bit-dithering corresponds to multiply the number of available output levels by 2, 2 bit-dithering corresponds to multiply the number of available output levels by 4 and 3 bit-dithering corresponds to multiply the number of availabl output levels by 8.

[0025] Looking at the table above, in particular to the input values less than 16 reveals that at minimum 3 bit-dithering is required to reproduce the 256 video levels more correctly with the required grey scale portrayal of a 'CRT' display device.

[0026] In the table above the columns headed 11 Bit Degamma Data contain the output data from the degamma unit. These values are derived from the values in the columns headed 16 Bit Degamma data by dividing them by 32 or better by truncation of 5 bits. How these values are used in the dithering process will be explained later on.

[0027] Next, the cell-based dithering will be explained in detail.

[0028] With cell-based dithering a dithering number is added to every panel cell in contrast to every panel pixel as usually done. A panel pixel is composed of three cells: red, green and blue cell. The cell-based dithering has the advantage of rendering the dithering noise finer and thus making it less noticeable to the human viewer.

[0029] Because the dithering pattern is defined cell-wise, it is not possible to use techniques like error-diffusion, in order to avoid colouring of the picture when one cell would diffuse in the contiguous cell of a different colour. This is not a big disadvantage, because it has been observed sometimes an undesirable low frequency moving interference, between the diffusion of the truncation error and a moving pattern belonging to the video signal. Error diffusion works best in case of static pictures.

[0030] Instead of using error diffusion, a static 3-dimensional dithering pattern is proposed according to this invention.

[0031] Fig. 3 shows one example for such a pattern. 3-bit-dithering is used in this example. This means that the dithering numbers have values from 0 to 7. The static 3-dimensional dithering pattern is defined for a cube of 4*4*4 cells (4-lines with 4 cells each, repeatedly taken from 4 frames). It is noted that this embodiment is only an example and that the number of dithering bits as well as the size and type of dithering pattern can be subject of modification in other embodiments of the invention.

[0032] The use of a 3 bit-dithering requires that the degamma operation is performed with 3 bits more than final resolution. The final resolution is given to be 8 bit resolution. The sub-field coding range is therefore from 0 to 255. Then the output range of the degamma operation should be from 0 to 2040. It is noted that the maximum dithering number with 3 bit dithering is 7. If this number is added to 2040, the result is 2047 which is the highest possible 11 bit binary number %11111111111. A slightly lower value than 2040. e.g. 2032 could also be used. This has the advantage that the corresponding values can simply be derived from the 16 bit degamma data by truncating the 5 least significant bits.

[0033] Some other examples: if sub-field coding range would be from 0 to 175, output range of degamma operation should be from 0 to 1400; and finally if coding range is from 0 to 127, output range should be from 0 to 1016. For every panel cell and for every frame, the corresponding dither pattern value is added to the output of the degamma function, and consequently truncated to the final number of bits.

[0034] The 3-bit dither pattern shown in Fig. 3 is static. This means that it is repeatedly used for the whol panel. From Fig. 3 it can be seen that the dither pattern is repeated in horizontal direction of the panel. However, it also repeats in vertical direction and in time direction accordingly.

[0035] It is noted that the proposed pattern, when integrated over time, always gives the same value for all panel cells. If this were not the case, under some circumstances, some cells could acquire an amplitude offset compared to other cells which would correspond to an undesirable fixed spurious static pattern.

[0036] Next, the principle of object-based dithering according to the invention is explained in greater detail. Object-based dithering corresponds to modify the number of dithering bits as a function of the displayed object. For this purpose different masking bit patterns are defined which serve as a selector for the dithering bit resolution. E.g., if the object-based dithering is used in combination with the cell-based dithering, the implementation of different dithering bit res-olutions can be done as follows.

[0037] The dithering pattern as shown in Fig. 3 remains unchanged. I.e., the dithering numbers have the 3 bit reso-lution as before at the beginning of the dithering process. This is the highest possible bit resolution in this example. For implementing the 4 different bit resolutions 3-bit, 2-bit, 1-bit and 0-bit, 4 different masking values are defined. These are:

3-bit dithering -> masko = %111 = 7H

2-bit dithering -> masko = %110 = 6H
1-bit dithering -> masko = %100 = 4H
0-bit dithering -> masko = %000 = OH

5   [0038]   These masking bit patterns are applied to the high resolution dithering numbers by Boolean operation. This can best be explained with some examples. In the examples below the Boolean operation is the logical AND operation.

3-Bit Dithering		
Dithering Number	Masking Bit Pattern	Result
%111	%111	%111
%110	%111	%110
%101	%111	%101
%100	%111	%100
%011	%111	%011
%010	%111	%010
%001	%111	%001
%000	%111	%000

2-Bit Dithering		
Dithering Number	Masking Bit Pattern	Result
%111	%110	%110
%110	%110	%110
%101	%110	%100
%100	%110	%100
%011	%110	%010
%010	%110	%010
%001	%110	%000
%000	%110	%000

1-Bit Dithering		
Dithering Number	Masking Bit Pattern	Result
%111	%100	%100
%110	%100	%100
%101	%100	%100
%100	%100	%100
%011	%100	%000
%010	%100	%000
%001	%100	%000
%000	%100	%000

0-Bit Dithering		
Dithering Number	Masking Bit Patt m	Result
%111	%000	%000
%110	%000	%000
%101	%000	%000
%100	%000	%000
%011	%000	%000
%010	%000	%000
%001	%000	%000
%000	%000	%000

[0039]   From the table for 3-bit dithering it is clear that the applied masking bit pattern has no effect on the dithering numbers. They remain unchanged and therefore, 3-bit dithering is preserved as wanted.

[0040]   From the table for 2-bit dithering it is clear that the applied masking bit pattern converts the 3-bit dithering numbers into 2-bit dithering numbers. There result only 4 different output values which corresponds to 2-bit dithering as wanted.

[0041]   From the table for 1-bit dithering it is clear that the applied masking bit pattern converts the 3-bit dithering numbers into 1-bit dithering numbers. There result only 2 different output values which corresponds to 1-bit dithering as wanted.

[0042]   From the table for 0-bit dithering it is clear that the applied masking bit pattern converts the 3-bit dithering numbers into 0-bit dithering numbers. Every input dithering number is converted to 0 which corresponds to 0-bit dithering as wanted.

[0043]   The dithering bit resolution selection with masking bit patterns has the advantage that there need not be different tables for dithering patterns and different algorithms. So that the presented solution is very efficient.

[0044]   In a practical application OSD insets are coded with 0-bit dithering while the video picture is coded with 3-bit dithering. If the plasma display panel is used as a monitor for computers, window borders and icons, as well as documents might be displayed with 0-bit dithering, while wall-papers and windows with motion pictures (video scenes); e. g. AVI-files or MPG-files might have 1-bit, 2-bit or 3-bit dithering enabled.

[0045]   If a video picture has been coded according to the MPEG-4 standard the object/region-based dithering can benefit from this coding. The MPEG-4 standard provides the tools for video object coding. This means that the different objects in a video scene are coded independently. In a further embodiment of the invention the number of dithering bits for the cells of an object in a picture are adapted to the kind and to the bit-resolution of the objects belonging to a given MPEG-4 sequence. For instance very often the background is darker than the rest of the picture and has low contrast. In this region the application of 3-bit dithering is therefore used. The foreground is very often brighter and mostly more rich in contrast. In this region 1 bit dithering is therefore more appropriate.

[0046]   Of course, object-based dithering requires some kind of information from the video source regarding video objects. This requires a picture content analysis which can be very complicated to implement. If in a low cost application this picture content analysis implementation is considered to be too expensive, then a low cost implementation of object-based dithering can be the restriction to switching off dithering in case of On-Screen-Display insets and switching on dithering for the rest of the picture.

[0047]   Next, the principle of amplitude-based dithering according to the invention is explained in greater detail. Amplitude-based dithering corresponds to modify the number of dithering bits as a function of the video component signal amplitude. This can be done in similar fashion like for the object-based dithering. There are also defined some masking bit patterns for the different amplitude ranges which are used to select a corresponding dithering bit resolution by Boolean operation with the dithering numbers.

[0048]   In video technology the video signal component value range is usually from 0 to 255 (8 bit words). This range is subdivided in e.g. 4 sections. The ranges and the assigned corresponding masking bit patterns are shown below:

For $(0 <= X < 32)$, maska = %111 = 7H,
for $(32 <= X < 64)$, maska = %110 = 6H,
for $(64 <= X < 128)$, maska = %100 = 4H,
for $(128 <= X <= 255)$, maska = %000 = 0H,

[0049] where X is the amplitude of the input video compon nt R,G,B.

[0050] According to this embodiment of the invention in the dithering circuit section the input video signal compon nts will be classified with respect to the amplitude rang . The dithering number from the dithering patt m is taken in 3-bit resolution and the logical AND operation is performed with the corresponding masking bit pattern. The resulting value is added to the video signal component data. This is done separately for each cell. The same principle is used for object-based dithering.

[0051] Next, it is explained in greater detail how the three different dithering techniques, cell-, amplitude- and object-based dithering can be combined for an optimisation.

[0052] Taking in consideration the above mentioned example with 3-bit dithering numbers, a combined solution can be described with the following formulae:

$$Rout = trunc [degamma [Rin] + (rdither [x,y,z] \text{ AND } maska [Rin,x,y,z] \text{ AND } masko [x,y,z])]$$

$$Gout = trunc [degamma [Gin] + (gdither [x,y,z] \text{ AND } maska [Gin,x,y,z] \text{ AND } masko [x,y,z])]$$

$$Bout = trunc [degamma [Bin] + (bdither [x,y,z] \text{ AND } maska [Bin,x,y,z] \text{ AND } masko [x,y,z])]$$

where

Rin denotes the video level of the red input video signal component R,
Gin denotes the video level of the green input video signal component G,
Bin denotes the video level of the blue input video signal component B,
degamma[ ] denotes the degamma function with 11 bit resolution,
maska[ ] denotes the amplitude-based masking value,
masko[ ] denotes the object-based masking value,
rdither[ ] denotes the cell based dithering number for the red cells according to the used dithering pattern,
gdither[ ] denotes the cell based dithering number for the green cells according to the dithering pattern,
bdither[ ] denotes the cell based dithering number for the blue cells according to the dithering pattern,
x denotes the panel pixel number,
y denotes the panel line number,
z denotes the frame number and
trunc [ ] denotes truncation to 8 bit resolution, i.e. truncation of the 3 least significant bits.

[0053] The expressions:

(rdither [x,y,z] AND maska [Rin,x,y,z] AND masko [x,y,z])],
(gdither [x,y,z] AND maska [Gin,x,y,z] AND masko [x,y,z])],
(bdither [x,y,z] AND maska [Bin,x,y,z] AND masko [x,y,z])]

therefore denote a resulting dithering number after combination with the masking bit patterns from object- and amplitude-based dithering.

[0054] The results of this calculations is illustrated in the following tables below. The results are only shown exemplarily for three input values 8, 21, 118. This is because the full table cannot be easily displayed on paper. The effect of dithering is however obvious already from the tables below. The first table concerns the example of 3-bit dithering. It is evident that for the input value 8 due to dithering the output value is changed from 0 to 1 in two cases compared to the embodiment without dithering. For the input value 21 the output value is changed from 1 to 2 in five cases compared to the case without dithering. For the input value 118 the output value is changed from 54 to 55 in three cases. Of course, the effect of dithering is becoming smaller as the input value increases because the ratio between dithering value to input value decreases.

Maska = masko = %111 = 3-bit dithering					
8 Bit Input Video Data	16 Bit Degamma Data	8 Bit Degamma Data	11 Bit Degamma Data	Dithering Number	8 Bit Output Video Data
8	64	0	2	7	1
				6	1
				5	0
				4	0
				3	0
				2	0
				1	0
				0	0
21	441	1	13	7	2
				6	2
				5	2
				4	2
				3	2
				2	1
				1	1
				0	1
118	13924	54	435	7	55
				6	55
				5	55
				4	54
				3	54
				2	54
				1	54
				0	54

[0055]   The next table lists the calculation results for 2-bit dithering. Here, the effect of dithering is of course getting smaller, as smaller dithering numbers are added. However, a difference is present only for the input value 18 where the output value is changed in only four cases and for the input value 118, where the output value is changed from 54 to 55 in only two cases.

Maska = masko = %110 = 2-bit dithering					
8 Bit Input Video Data	16 Bit Degamma Data	8 Bit D gamma Data	11 Bit Degamma Data	Dithering Number	8 Bit Output Video Data
8	64	0	2	7	1
				6	1
				5	0
				4	0
				3	0
				2	0
				1	0
				0	0
21	441	1	13	7	2
				6	2
				5	2
				4	2
				3	1
				2	1
				1	1
				0	1
118	13924	54	435	7	55
				6	55
				5	54
				4	54
				3	54
				2	54
				1	54
				0	54

[0056]   The next table lists the calculation results for 1-bit dith ering. Here, the effect of dithering has vanished for the input vales 8 and 118 but for the input value 21 there is still the effect that the output values have been changed from 1 to 2 in four cases. Of course there are other input values, like 12, where the effect is maintained.

Maska = masko = %100 = 1-bit dithering					
8 Bit Input Video Data	16 Bit Degamma Data	8 Bit D gamma Data	11 Bit Degamma Data	Dithering Number	8 Bit Output Video Data
8	64	0	2	7	0
				6	0
				5	0
				4	0
				3	0
				2	0
				1	0
				0	0
21	441	1	13	7	2
				6	2
				5	2
				4	2
				3	1
				2	1
				1	1
				0	1
118	13924	54	435	7	54
				6	54
				5	54
				4	54
				3	54
				2	54
				1	54
				0	54

[0057] In Fig. 4 a circuit implementation of the invention is illustrated. Input R,G,B video data is forwarded to degamma unit 10 and a dither evaluation unit 12. The degamma unit 10 performs the 11-bit degamma function and delivers 11 bit video data R,G,B at the output. The dither evaluation unit 12 computes the dithering numbers: DR for red, DG for green and DB for blue. To do that it requires the sync signals H and V to determine which pixel is currently processed and which line and frame number is valid. These information is used for addressing a lookup table in which the dithering pattern is stored. The R, G and B components are used in this unit for evaluating the amplitude masking values maska. The masking value MO, which is the object-based masking value for the current pixel, is delivered by a unit in the video source, like MPEG4 decoder. This unit is not shown. In the case that no such unit is available, the signal MO can be replaced by the fast blanking signal of an external OSD insertion circuit. Unit 12 also performs the Boolean operations according to above discussed formulae. In calculation unit 11 the resulting dithering numbers and the degamma output values are added and the 3 least significant bits of the result are truncated so that the final output values Rout, Gout and Bout are achieved. These values are forwarded to a sub-field coding unit 13 which performs sub-field coding under control of control unit 16. The sub-field code words are stored in memory unit 14. Reading and writing from and to this memory unit is also controlled by the external control unit 16. For plasma display panel addressing, the sub-field cod words are read out of the m mory device and all th code words for one line a collected in order to create a single very long code word which can be used for th line wise PDP addressing. This is carri d out in the serial to parallel conv rsion unit 15. The control unit 16 generat s all scan and sustain pulses for PDP control. It receives horizontal

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and vertical synchronising signals for reference timing.

[0058]   The invention can be used in particular in PDPs. Plasma displays are currently used in consumer electronics, e.g. for TV sets, and also as a monitor for computers. However, use of the invention is also appropriate for matrix displays where the light emission is also controlled with small pulse in sub-fields, i.e. where the PWM principle is used for controlling light emission.

Claims

1. Method for processing video picture data for display on a display device having a plurality of luminous elements corresponding to the colour components of pixels of a video picture, wherein a dithering method is applied to the video data to refine the grey-scale portrayal in the video pictures, **characterized in that,** the dithering method includes one or more of the following specialities singly or in combination:

   the dithering is made cell-based, i.e. to each colour component R, G, B of a pixel separate dithering numbers are added;
   the set of disposable dithering numbers is made dependent on the region/object in the video picture;
   the set of disposable dithering numbers is made dependent on the video (signal) level.

2. Method according to claim 1, wherein for the cell-based dithering the video picture is divided into a number of sections and a static 3-dimensional dithering pattern is defined which is used repeatedly in a video sequence, wherein a first dimension corresponds to a video line number, a second dimension corresponds to a number of pixels within a video line section and a third dimension corresponds to a number of video frames.

3. Method according to claim 2, wherein the static 3-dimensional dithering pattern is defined for a section of 4 lines with 4 pixels each for a number of 4 consecutive frames with a bit-resolution for the dithering numbers of 3 bits.

4. Method according to one of the previous claims, wherein for the region/object-based dithering, the information about different video objects/region is taken over from an MPEG4 data stream.

5. Method according to one of the previous claims, wherein to each of the specific sets of disposable dithering numbers for the dithering process, a corresponding masking bit pattern is assigned which determines by Boolean operation which of the bits of a high resolution dithering number are to be taken for the resulting final dithering number.

6. Method according to one of the previous claims, wherein for the video level-based dithering, the full video level range is subdivided in a number of sections and to each section a corresponding masking bit pattern is assigned which determines by Boolean operation which of the bits of a high resolution dithering number are to be taken for the resulting final dithering number.

7. Method according to claim 6, wherein the full video level range from 0 to 255 is subdivided in 4 sections, in particular 0 to 31, 32 to 63, 64 to 127, and 128 to 255 and correspondingly the following bit resolutions are used for the ranges, 3-bit, 2-bit, 1-bit, 0-bit and wherein the bit resolution decreases as the video level range increases.

8. Method according to one of the previous claims, wherein for the combined use of all the dithering specialities the following formulae are applied:

$$Rout = trunc[degamma[Rin] + (rdither[x,y,z] \text{ AND } maska[Rin,x,y,z] \text{ AND } masko[x,y,z])]$$

$$Gout = trunc[degamma[Gin] + (gdither[x,y,z] \text{ AND } maska[Gin,x,y,z] \text{ AND } masko[x,y,z])]$$

$$Bout = trunc[degamma[Bin] + (bdither[x,y,z] \text{ AND } maska[Bin,x,y,z] \text{ AND } masko[x,y,z])],$$

where

Rin d notes the video level of th red input vid o signal compon nt R,

Gin denotes the video lev l of the green input vid o signal component G,

Bin d notes th video level of the blu input vid o signal component B,

degamma[ ] denotes the degamma function with specific bit resolution, in particular 11-bit resolution,

maska[ ] denotes the amplitude-based masking value, masko[ ] denotes the object-based masking value,

rdither[ ] denotes th cell-based dithering numb r for the red cells according to th used dithering pattern,

gdither[ ] denotes the cell-based dithering number for the green cells according to th used dithering pattern,

bdither[ ] denotes the cell-bas d dithering number for the blu cells according to the used dithering pattern,

x denotes the panel pixel number,

y denotes the panel line number,

z denotes the frame number, and trunc[ ] denotes truncation to.a specific bit resolution, in particular 8-bit resolution.

9. Use of the method according to one of the previous claims, for the video signal processing in a Plasma display device.
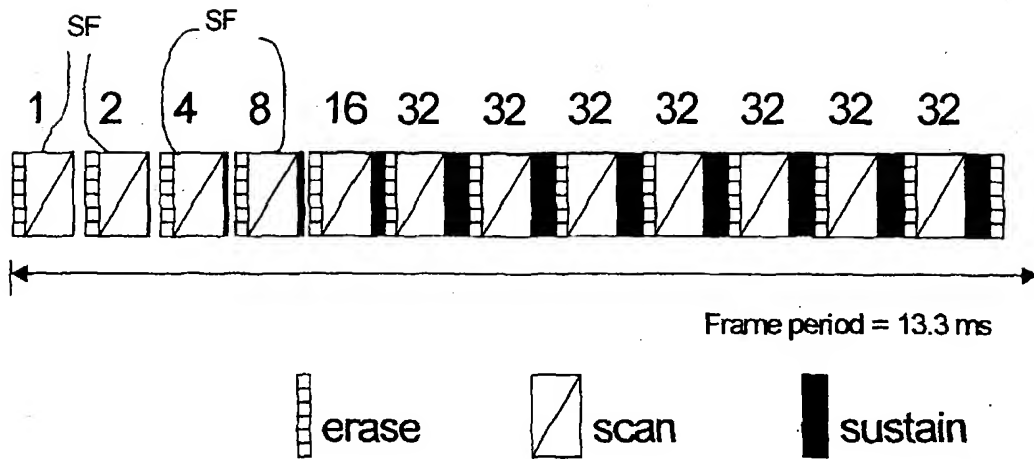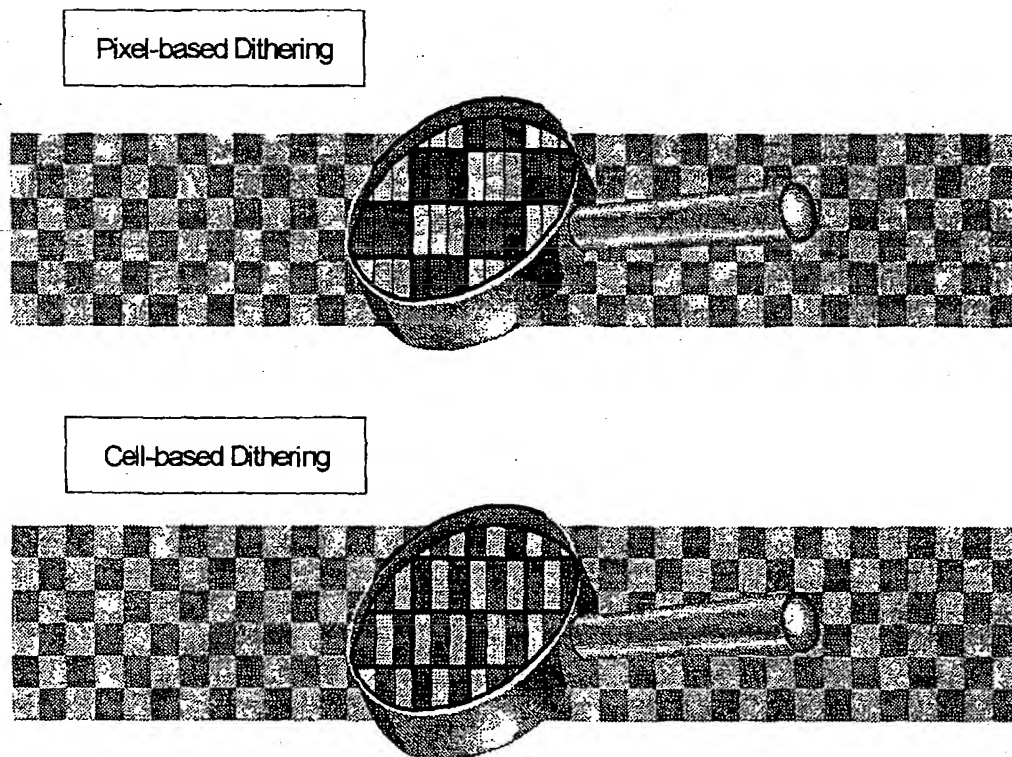
SF   SF

| 1 | 2 | 4 | 8 | 16 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |

Frame period = 13.3 ms

▥ erase   ◹ scan   ∎ sustain

Fig. 1

Pixel-based Dithering

Cell-based Dithering

Fig. 2

FRAME 1

	R	G	B	R		G	B	R	G
line 1	7	3	6	2		7	3	6	2
line 2	0	4	1	5		0	4	1	5
line 3	6	2	7	3		6	2	7	3
line 4	1	5	0	4		1	5	0	4

FRAME 2

	R	G	B	R		G	B	R	G
line 1	4	0	5	1		4	0	5	1
line 2	3	7	2	6		3	7	2	6
line 3	5	1	4	0		5	1	4	0
line 4	2	6	3	7		2	6	3	7

FRAME 3

	R	G	B	R		G	B	R	G
line 1	2	6	3	7		2	6	3	7
line 2	5	1	4	0		5	1	4	0
line 3	3	7	2	6		3	7	2	6
line 4	4	0	5	1		4	0	5	1

FRAME 4

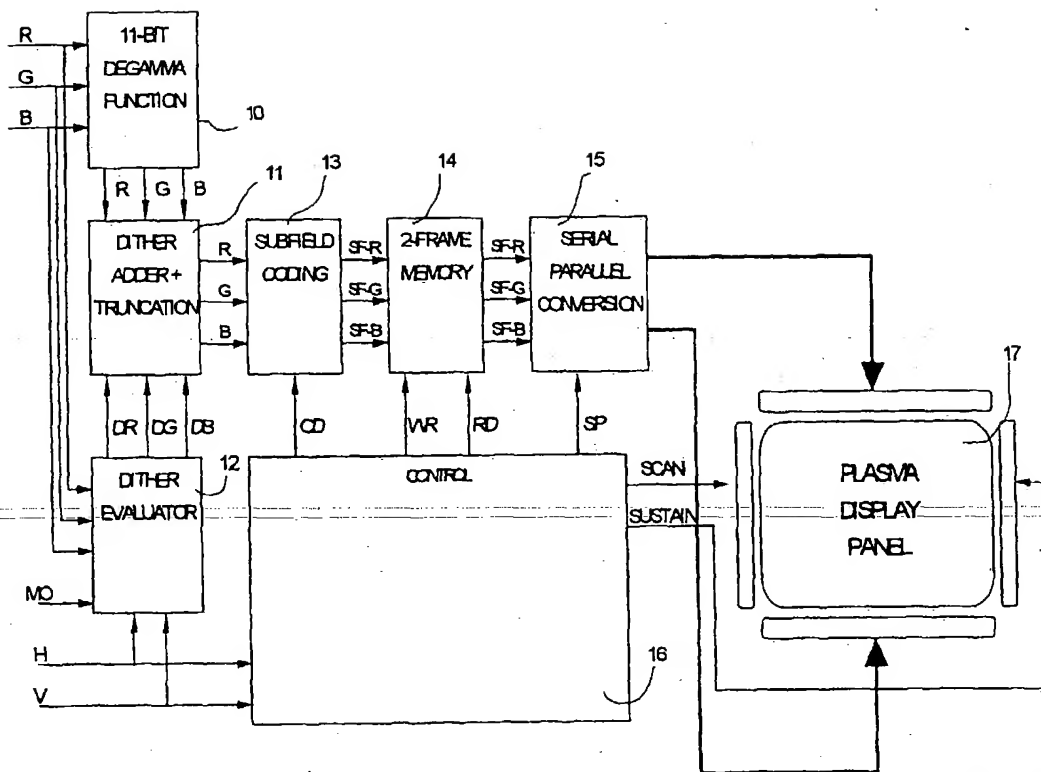|	R	G	B	R		G	B	R	G
line 1	1	5	0	4		1	5	0	4
line 2	6	2	7	3		6	2	7	3
line 3	0	4	1	5		0	4	1	5
line 4	7	3	6	2		7	3	6	2

Fig. 3

Fig. 4

European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 00 25 0099

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A	* abstract * * page 3, line 8 - line 10 * * page 3, line 46 - line 51 * * page 6, line 49 - line 54; figures 1-10 *	4,7,8	
X	US 5 301 269 A (ALCORN ET AL) 5 April 1994 (1994-04-05)	1-3,5,9	
A	* abstract * * column 4, line 54 - line 56 * * column 6, line 13 - line 31; figures 1-7 *	4,7,8	
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A	* abstract * * column 6, line 46 - column 7, line 9; figures 1-6 *	4,7,8	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	6 September 2000	O'Reilly, D

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